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Children and adolescents admitted to a university-level trauma centre in Denmark 2002-2011

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ABSTRACT

INTRODUCTION: The epidemiology of children or adolescents admitted to a Scandinavian trauma centre is largely unknown. The aim of this paper was to describe the epidemiology and severity of potentially severely injured children and adolescents admitted to a university hospital trauma centre.

METHODS: This was a descriptive study of all children and adolescents aged 0-17 admitted to the university level trauma centre at Odense University Hospital, Denmark in the 2002-2011 period. Data were extracted from the Southern Danish Trauma Register and from medical records.

RESULTS: A total of 950 children and adolescents were included. The median age was 13 (range: 0-17) years. Boys accounted for 60.6% of the cases. Accidents accounted for 97.2%, violence 1.4% and self-inflicted injuries 0.4%. More than three fourths of the injuries occurred either in traffic or at home. The occurrence was greatest in the summer (34.0%), during weekends (48.9%) and in the hours between 12.00 and 20.00 (59.2%). Overall, 58.5% of the injuries were due to traffic. Of these injuries, 39.7% were injuries suffered by passengers in motor vehicles, 27.5% drivers/passengers of a scooter/MC, 21.8% bicyclists and 10.3% pedestrians. The median Injury Severity Score (ISS) and Abbreviated Injury Scale was 4 (range: 1-75) and 2 (range: 1-6), respectively. Head/face injuries accounted for 36.5% and injuries to the extremities for 30.9% of all injuries. A total of 153 (16.1%) suffered from severe injuries (ISS > 15). Overall, 49 (5.2%) died due to their injuries.

CONCLUSIONS: Based on a local trauma register, we described the epidemiology and severity of potentially severely injured children and adolescents admitted to a university trauma centre.

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Severe injury in young adolescents and children is relatively rare. However, from infancy to adulthood, injuries are the main reason of death in the industrial countries [1-3]. In 2002 and 2011, 68 and 62 deaths due to injuries in the age group 0-19 years were registered in Denmark, corresponding to 12% and 16% of all deaths in that the age group, respectively [4].

The epidemiology of children or adolescents admitted to a Scandinavian trauma centre is largely unknown. Only one Scandinavian study describing the epidemiology of severe injuries among children and adolescents has been published [5]. In this Swedish study from the Intensive Care Unit Database in Gothenburg, the majority of the injured patients were boys (68%), 40% of injuries were traffic-related and 34% were due to fall accidents [5]. Head injuries accounted for 30% of the injuries and the overall mortality was 3%.

Some non-Scandinavian studies have been published. These studies have shown that severe injuries are most frequent among boys [6-9]. The median age varies between 7.9 and 13 years due to differences in inclusion criteria [6-10]. Traffic-related injuries are the most common [6, 7, 9, 11], and head injuries are the most common type of injury in most studies [5, 6, 10]. The mortality varied between 1.5% and 8% [6, 7, 9, 11].

The clinical implication of this information is improved preparedness owing to enhanced knowledge about which types of injury and impacts may be expected as a receiving traumatologist and how specialist competence may be organised for treatment of acute trauma patients.

The aim of this study was to describe the epidemiology and severity for different age groups of potentially severely injured children and adolescents admitted to a university-level trauma centre.

METHODS

In the study period from 2002-2011, all injured children and adolescents aged 0-17 years who were received by trauma teams at the university level trauma centre at Odense University Hospital (OUH), Denmark, were included. Included were patients primarily brought to the hospital as well as those transferred from another hospital within 24 hours after their trauma occurred. Trauma team reception was given based on strict criteria (**Table 1**). In all patients, a total score of two points or more according to the criteria in Table 1 triggered trauma team reception. In the study period, minor revisions of the criteria were implemented. High-energy trauma was defined as a fall from more than six metres, pedestrian/bicyclist hit by a car, dead person in same car, person thrown from car/motorcycle, car turned over, person trapped for more than 20 minutes or larger deformity of the car. Excluded according to the UTSTEIN

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TABLE 1

The criteria leading to trauma team reception at Odense University Hospital. A total score ≥ 2 points automatically leads to trauma team reception.

	Points		
Criterion	**0**	**1**	**2**
Trauma mechanism	Low energy	High energy	–
Breathing	Normal	Difficulties	No breathing/intubation
Circulation	Blood pressure > 90 mmHg	–	Blood pressure < 90 mmHg
Level of consciousness	Awake	Decreased awakeness	Unconsciousness
Thorax	No tenderness/pain	Tender/pain	Open lesion
Abdomen	No tenderness/pain	Tender/pain	Open lesion
Spine	No tenderness/pain	Tender/pain	Open lesion
Face, pelvis or limbs	No tenderness/pain	Visible fracture	Paralysed
Total score			

criteria were persons who died prior to arrival to the hospital and persons who were strangled, drowned or seriously burned [12, 13].

The university hospital trauma centre at OUH provides services for the Region of Southern Denmark with a population of approximately 1,000,000 and is located in the city centre of Odense with a population of 190,000 inhabitants. In addition to the university level trauma centre, four regional trauma centres provide services for the region. Occasionally, the university-level trauma centre also receives trauma patients from other parts of Denmark.

Since 1996, all trauma patients admitted to the trauma centre have been registered in the South Danish Trauma Register. The register contains detailed information about demography, the circumstances leading to injury, place of injury, diagnoses, treatment and outcome. The trauma patients are registered prospectively and consecutively on admission to the trauma centre. The trauma register includes self-reported information from the patient, information from the police/paramedics and information from the medical records. All registration were made by trained staff. Trained physicians determine the diagnoses according to the International Classification of Diseases, tenth version (ICD10) with a maximum of ten diagnoses in each patient. For those patients who die, diagnoses are obtained from the autopsy reports. All autopsies of trauma patients are made at the Institute of Forensic Medicine, University of Southern Denmark.

The injury severity is coded using the Abbreviated Injury Scale (AIS) after which the Injury Severity Score (ISS) is calculated [14]. AIS is a numerical scale where the last digit indicates the severity of every injury [14]. It ranges from 1 (abrasions and small wounds) to 6 (deadly lesion) [14]. The ISS is calculated from the AIS as the sum of the square root of the highest AIS value (last number) in the three most wounded anatomic regions of the body. In this study, severely injured children are defined as ISS > 15.

The data were analysed following stratification into age groups: 0-3 years (infants), 4-9 years (small children), 10-15 years (older children) and 15-16 years (adolescents). These groups were made after the initial analyses of the data. Patients within each group have several similarities regarding place of injury, injury pattern, etc. Non-parametric statistics with STATA 10 was used in all statistical analyses and $p < 0.05$ was considered statistically significant. The study was approved by the Danish Data Protection Agency.

Trial registration: not relevant.

RESULTS

In the study period, we included 950 potentially severely injured children and adolescents aged 0-17 years, corresponding to 95 patients per year. Overall, 779 (82%) were primary admissions and 171 (18%) were transferred from other hospitals. In total, 923 (97%) of the casualties were accidents, 13 (1%) were caused by violence, four (< 1%) were self-inflicted injuries, and in ten (1%) cases the cause of injury was unknown.

In all, 60.6% were boys (gender ratio: 1.5). The overall median age was 13 years (range: 0-17 years), whereas the median age among boys and girls was 14 years (range: 0-17) and 13 years (range: 0-17 years) (Wilcoxon, p = 0,0003), respectively. Almost two thirds of the injuries occurred in traffic areas (**Table 2**). However, for infants (0-3 years) most injuries occurred in residential areas.

The 950 injured persons suffered from a total of 2,125 lesions corresponding to 2.2 lesions per patient. The majority of lesions were to the head, face and limbs (**Table 3**). The median ISS was 4 (range: 1-75). Overall, 16.1% suffered from severe injuries (ISS > 15). The proportion of severe injuries was highest among adolescents (20.2%). 64% of the severely injured (ISS > 15) had head injuries compared with 34% of those with less severe (ISS ≤ 15) injuries. Conversely, the proportion of

limb injuries decreased with increasing injury severity. The proportion of injuries in traffic areas increased with injury severity. In the severely injured cases (ISS > 15), 71% were injured in traffic areas, whereas this was the case for 60% in the group of less severely injured cases (ISS ≤ 15).

The median period in hospital was two days (range: 1-133) with no significant difference between age groups (Kruskal-Wallis, p = 0.5826). Overall, 5.2% died due to their injuries. The mortality was 5.9% for boys and 4.0% for girls. More than half of all deaths among boys occurred in the age group 16-17 years, and among girls more than half of deaths occurred in the age group 10-15 years. Among those who died, 84% were injured in traffic areas, 10% in domestic areas and 6% in working areas. Of these, 61% had severe injuries to the head including cerebral haemorrhages.

A total of 556 (58.5%) were injured in traffic accidents (**Table 4**). The proportion of traffic-related injuries increased with increasing age group (0-3 years: 31.4%, 4-9 years: 44.0%, 10-15 years: 59%, 16-17 years: 75.8%). Overall 63.7% were boys. The overall median age was 15 (range: 0-17) years, whereas the median age among boys and girls was 15 (range: 0-17) and 14 (range: 0-17) years, respectively (Wilcoxon, p < 0.005). The majority of children and adolescents were passengers in vehicles (≥ 4 wheels). The median ISS among traffic injuries was 4 (range: 1-75). Overall, 17.8% suffered from severe injuries (ISS > 15). The proportion of severe injuries was highest among adolescents aged 16-17 years (20.5%). The overall mortality was 6.3%.

DISCUSSION

Based on a local trauma register, we described the epidemiology and severity of potentially severely injured children and adolescents admitted to a Danish university level trauma centre with all medical specialties. The distribution of age and gender was similar to the findings reported in previous studies [5-10].

In line with results reported from other studies, boys accounted for the highest number of traumas [5-9]. Additionally, we found that traumas among the youngest children were less common, which corresponds with the findings reported from other studies [5, 6, 7, 9]. Only 15.5% of the traumas occurred at school and institutional areas. This is a relative small proportion compared with the amount of time children spend within these areas. However, the location of traumas seemed to vary with age groups. In the age group 0-3 years, half of the traumas occurred within the residential area. With increasing age, traffic area becomes the predominant site of trauma. A previous study describes a similar trend [6]. The highest frequency of multi trauma occurred in the summer time, in the weekends (Friday-Sunday) and in the day time between 12.00-19.59. These findings are in line with the findings reported by most other studies [5, 6, 9, 15]. School holidays with long days of leisure activities is a possible explanation for this, since schools, according to this study, seem to be a relatively safe institution. In our study, the mean number of injuries was 2.2 injuries per child. The mean number increased with age as did the proportion of lesions in the limbs and spine. This may be explained by the increased number of traffic accidents among older children, as spinal injuries are generally associated with high-energy traumas. The median ISS was 4 and only 16.1% of the trauma patients in our study were severely injured (ISS > 15), which indicates that the majority of the trauma patients in our study were mildly injured. This is owed to the criteria of the multi trauma register, where just a suspicion of multiple traumas is sufficient to fulfil the prerequisites of trauma team activation and subsequent registration in the trauma registry.

Among traumas related to traffic, 39.7% were passengers in a motor vehicle (≥ 4 wheels). Pedestrians

TABLE 2

The distribution of gender and injury characteristics stratified by age groups. The values are n (%).

	Age group				
	0-3 yrs	4-9 yrs	10-15 yrs	16-17 yrs	Total
Gender					
Male	56 (53.3)	102 (58.3)	205 (55.7)	213 (70.5)	576 (60.6)
Female	49 (46.7)	73 (41.7)	163 (44.3)	89 (29.5)	374 (39.4)
Location of injury					
Traffic area	31 (29.5)	80 (45.7)	230 (62.5)	246 (81.5)	587 (61.8)
Residential area	58 (55.2)	42 (24.0)	35 (9.5)	13 (4.3)	148 (15.6)
Working area	2 (1.9)	4 (2.3)	8 (2.2)	8 (2.6)	22 (2.3)
Institution/school	6 (5.8)	35 (20.0)	79 (21.5)	27 (9.0)	147 (15.5)
Unknown	8 (7.7)	14 (8.0)	16 (4.4)	8 (2.7)	46 (4.9)
Time of injury, hours					
00:00-07:59	4 (3.9)	3 (1.7)	30 (8.1)	58 (19.2)	95 (10.0)
08:00-15:59	45 (42.8)	81 (46.2)	147 (39.9)	104 (34.4)	377 (39.7)
16:00-23:59	50 (47.6)	72 (41.2)	171 (46.5)	113 (37.4)	406 (42.8)
Unknown	6 (5.7)	19 (10.9)	20 (5.4)	27 (8.9)	72 (7.6)
Weekday of injury					
Monday	10 (9.5)	27 (15.4)	58 (15.8)	32 (10.6)	127 (13.4)
Tuesday	12 (11.4)	19 (10.9)	46 (12.5)	37 (12.3)	114 (12.0)
Wednesday	11 (10.5)	23 (13.1)	33 (9.0)	44 (14.6)	111 (11.7)
Thursday	16 (15.2)	25 (14.3)	53 (14.4)	39 (12.9)	133 (14.0)
Friday	15 (14.3)	31 (17.7)	55 (14.9)	54 (17.9)	155 (16.3)
Saturday	19 (18.1)	22 (12.6)	50 (13.6)	49 (16.2)	140 (14.7)
Sunday	22 (21.0)	28 (16.0)	73 (19.8)	47 (15.6)	170 (17.9)
Season of injury					
Dec-Feb	19 (18.1)	27 (15.4)	59 (16.0)	44 (14.6)	149 (15.7)
Mar-May	29 (27.6)	56 (32.0)	102 (27.8)	66 (21.9)	253 (26.6)
Jun-Aug	38 (36.2)	59 (33.7)	120 (32.6)	106 (35.1)	323 (34.0)
Sep-Nov	19 (18.1)	33 (18.9)	87 (23.6)	86 (28.5)	225 (23.7)
Total	105 (100.0)	175 (100.0)	368 (100.0)	302 (100.0)	950 (100.0)

TABLE 3

The total number of injuries in different body regions, the Injury Severity Score, the number of days in hospital, and the mortality stratified by age groups. The values are n (%).

	Age group				
	0-3 yrs	4-9 yrs	10-15 yrs	16-17 yrs	Total
Body region injured					
Head or face	110 (55.0)	149 (4 4.9)	290 (35.2)	227 (29.6)	776 (36.5)
Neck	1 (0.5)	3 (0.9)	9 (1.1)	9 (1.2)	22 (1.0)
Thorax	21 (10.5)	43 (13.0)	92 (11.2)	99 (12.9)	255 (12.0)
Internal organs	15 (7.5)	35 (10.5)	84 (10.2)	70 (9.1)	204 (9.6)
Spine	6 (3.0)	22 (6.6)	78 (9.5)	77 (10.0)	183 (8.6)
Upper limbs	16 (8.0)	33 (9.9)	118 (14.3)	125 (16.3)	292 (13.7)
Lower limbs	25 (12.5)	45 (13.6)	147 (17.8)	148 (19.3)	365 (17.2)
Unspecified	6 (3.0)	2 (0.6)	7 (0.8)	13 (1.7)	28 (1.3)
Sum	200 (100.0)	332 (100.0)	825 (100.0)	768 (100.0)	2,125 (100.0)
Injury Severity Score					
1-6: mild	67 (63.8)	118 (67.4)	243 (66.1)	182 (60.3)	610 (64.2)
7-15: moderate	19 (18.1)	38 (21.7)	71 (19.3)	59 (19.5)	187 (19.7)
> 15: severe	19 (18.1)	19 (10.9)	54 (14.7)	61 (20.2)	153 (16.1)
Time in hospital, days					
0	9 (8.6)	14 (8.0)	50 (13.6)	29 (9.6)	102 (10.7)
1	19 (18.1)	26 (14.9)	55 (14.9)	74 (24.5)	174 (18.3)
2-3	45 (42.8)	80 (45.7)	159 (43.2)	103 (34.1)	387 (40.7)
4-7	21 (20.0)	32 (18.3)	57 (15.5)	36 (11.9)	146 (15.4)
8-14	7 (6.7)	14 (8.0)	31 (8.4)	34 (11.3)	86 (9.1)
> 14	4 (3.8)	9 (5.2)	16 (4.4)	24 (8.2)	54 (5.7)
Mortality					
Survived	100 (95.2)	173 (98.9)	350 (95.1)	278 (92.1)	901 (94.8)
Died	5 (4.8)	2 (1.1)	12 (4.9)	13 (7.7)	49 (5.2)
Total	105 (100.0)	175 (100.0)	368 (100.0)	302 (100.0)	950 (100.0)

TABLE 4

Traffic-related injuries. gender, role in traffic, Injury Severity Score, and mortality. The values are n (%).

	Age group				
	0-3 yrs	4-9 yrs	10-15 yrs	16-17 yrs	Total
Gender					
Male	16 (48.5)	44 (57.1)	126 (58.1)	168 (73.4)	354 (63.7)
Female	17 (51.5)	33 (42.9)	91 (41.9)	61 (26.6)	202 (36.3)
Role of traffic					
Pedestrian	8 (24.2)	17 (22.1)	26 (12.0)	6 (2.6)	57 (10.3)
Bicycle	0	17 (22.1)	70 (32.3)	34 (14.8)	121 (21.8)
Moped	0	0	41 (18.9)	112 (48.9)	153 (27.5)
Vehicle ≥ 4 wheels	23 (69.7)	41 (53.2)	80 (36.9)	77 (33.6)	221 (39.7)
Other	0	1 (1.3)	0	0	1 (0.2)
Unknown	2 (6.1)	1 (1.3)	0	0	3 (0.5)
Injury Severity Score					
1-6: mild	21 (63.6)	56 (72.1)	131 (60.4)	135 (59.0)	343 (61.7)
7-15: moderate	6 (18.2)	12 (15.6)	49 (22.6)	47 (20.5)	114 (20.5)
> 15: severe	6 (18.2)	9 (11.7)	37 (17.1)	47 (20.5)	99 (17.8)
Mortality					
Survived	31 (93.9)	76 (98.7)	202 (93.1)	212 (92.6)	521 (93.7)
Died	2 (6.1)	1 (1.3)	15 (6.9)	17 (7.4)	35 (6.3)
Total	33 (100.0)	77 (100.0)	217 (100.0)	229 (100.0)	556 (100.0)

accounted for a relatively small proportion (10.3%) of traffic traumas in this study. Other studies found pedestrians to be the most vulnerable group with the most serious injuries [5, 16].

One of the strength of our study was that data were collected for a relatively long period of time, resulting in a large study population. Additionally, the number of unknown variables is relatively limited.

The AIS measurement is based on anatomical regions because of the AIS criteria [14]. This approach has some limitations. The AIS weighs all anatomic regions equally. An AIS score for a head lesion may be more severe than a lesion in the upper extremities receiving the same score. Patients may therefore have the same ISS score but a different risk of death. In addition, calculation of ISS includes only three injuries, one for each of the three most severely injured anatomical regions. Therefore, patients with more than one serious injury within the same body region may receive an underestimated ISS score [17-19]. Despite this limitation, the AIS/ISS remains the most reliable and valid tool for measuring the immediate severity of injuries.

Several biases may have influenced the data. In 2009, the multi-trauma registry changed the contents to the Utstein criteria [20]. Thus, minor changes in exclusion criteria and definitions may have caused bias. However, we believe that the extent of this bias is limited. Secondly, the triage criteria used to decide whether an incoming trauma triggers trauma reception may have resulted in under-triage as severely injured patients may not be received by a trauma team. We consider the bias from under-triage to be very limited.

The different age groups of unequal sizes made it difficult to compare our results with those of other studies. However, we wanted the age groups to reflect different stages in life, e.g. infants, younger children, older children and adolescents.

CONCLUSIONS

Based on the Southern Danish Trauma Register, we described the epidemiology and severity of potentially severely injured children and adolescents admitted to a university level trauma centre. The study included several aspects regarding injury pattern and severity, which may be useful in a population for risk identification, prevention of accidents among specific subgroups, and for hospital resource planning.

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